

## **CLAIM AMENDMENTS**

### **Claim Amendment Summary**

#### **Claims pending**

- Before this Amendment: Claims 1, 3-41, and 45-48.
- After this Amendment: Claims 1, 3-11, 13, 14, 16, 17, 19-24, 26-39, 41, and 45-48.

**Canceled claims:** 12, 15, 18, 25, and 40

**Amended claims:** 1, 3-5, 7, 9-11, 13, 14, 16, 20, 24, 27-30, 35-39, 41, 45, and 48.

**New claims:** None

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#### **Claims:**

1. **(Currently Amended)** A method, comprising:  
receiving a facial image;  
creating a line-drawing from the facial image;  
computing a set of semantic facial features from key points of a face in the facial image to describe a geometric shape of the face;  
comparing relationships among the semantic facial features to corresponding relationships between unexaggerated and exaggerated features in reference facial images and associated reference caricatures drawn by an artist and stored in a reference database of caricatures drawn by an artist;

applying a kernel regression to select some of the semantic facial features in the facial image for caricature exaggeration and to exaggerate the semantic facial features into exaggerated features, wherein a nonlinear mapping between corresponding unexaggerated and exaggerated features in the reference database is learned via the kernel regression;

selecting a relationship among facial features of the facial image to exaggerate based on a variance of the relationship from a norm derived from the reference facial images in the reference database, wherein relationships having relatively high variance from the norm are selected for exaggeration, wherein the selecting a relationship comprises:

performing a kernel regression in order to map the relationship to similar relationships among similar facial features in the reference facial images;

assigning weights to the reference facial images based on a similarity of the relationship to corresponding relationships among facial features in the facial images, wherein a high weight is assigned to a high similarity; and

applying a linear regression to the weighted facial images generating from the facial image, an exaggerated face shape by applying a maximum likelihood estimation (MLE) to the exaggerated features of the facial image; and

morphing the line-drawing into the exaggerated face shape to create a facial caricature; caricature, wherein:

wherein for each semantic facial feature to be exaggerated the a degree of exaggeration is determined by the kernel regression; and

wherein the degree of exaggeration of each feature to be exaggerated is adjustable by a user.

## **2. (Cancelled)**

**3. (Currently Amended)** The method as recited in claim 2, claim 1, wherein the kernel regression technique assigns various weights to the reference facial images and associated caricatures based on a similarity to one or more relationships among facial features in the line-drawing.

**4. (Currently Amended)** The method as recited in claim 1, wherein creating a line-drawing includes rendering the facial image into a set of points, wherein at least some of the points describe at least some of the facial features and wherein at least some distances between the points represent at least one relationship among facial features.

**5. (Currently Amended)** The method as recited in claim 1, further comprising constraining the automatic exaggerating of a relationship among facial features to maintain the facial image within a range of probable faces.

**6. (Original)** The method as recited in claim 5, wherein the constraining is based on a likelihood that the exaggerating conforms to allowable exaggerations in the associated caricatures.

**7. (Currently Amended)** The method as recited in claim 5, wherein the constraining ~~further~~ includes:

deriving a first map representing differences between the line-drawing of the facial image and the facial image after the exaggerating;

deriving a second map representing averaged differences between the reference facial images and their associated caricatures; and

comparing the first map against the second map;

adjusting at least some of the differences in the first map to more closely approximate corresponding differences in the second map; and

adjusting an exaggerated relationship based on the adjusted first map.

**8. (Original)** The method as recited in claim 7, wherein the adjusting at least some of the differences in the first map to more closely approximate corresponding differences in the second map uses a maximum likelihood model.

**9. (Currently Amended)** The method as recited in claim 5, wherein the constraining includes:

deriving a map representing differences between the line drawing of the facial image and the facial image after the exaggerating;

selecting one of the associated-reference caricatures based on a similarity to the map; and

conforming the exaggerating to the selected reference caricature, wherein if exaggeration of a relationship varies beyond a threshold from a corresponding relationship in the selected reference caricature, then a degree of the exaggerating of the facial image is altered to conform to the relationship in to the selected reference caricature.

**10. (Currently Amended)** The method as recited in claim 9, wherein the selecting one of the reference caricatures uses a maximum likelihood technique.

**11. (Currently Amended)** The method as recited in claim 9, further comprising variably combining the line-drawing of the facial image with the selected reference caricature in order to produce a variably exaggerated caricature of the facial image.

**12. (Canceled)**

**13. (Currently Amended)** The method as recited in claim 1 claim 12, wherein the variance of the relationship from the norm is determined by:

measuring one or more distances representing the relationship among facial features of the facial image; and

comparing the one or more distances with corresponding average distances in the reference facial images.

**14. (Currently Amended)** The method as recited in claim 1 claim 12, wherein the selecting a relationship includes:

performing a kernel regression in order to map the relationship to similar relationships among similar facial features in the reference facial images; and

selecting the relationship for exaggeration if the relationship varies by a threshold from an average for the similar relationships.

**15. (Cancelled)**

**16. (Currently Amended)** The method as recited in claim 1 claim 12, wherein the selecting a relationship includes:

measuring one or more distances representing the relationship among facial features of the facial image;

assigning weights to the facial images based on a similarity of the relationship to corresponding relationships among facial features in the facial images, wherein a high weight is assigned to a high similarity; and

selecting the relationship for the exaggerating if one or more distances representing the relationship vary beyond a first threshold from one or more corresponding average distances among facial features derived from the reference facial images that are assigned a weight that exceeds a second threshold.

**17. (Original)** The method as recited in claim 1, further comprising varying a degree of the exaggerating to be applied to a relationship among facial features while constraining the exaggerating in order to maintain the facial image within a range of probable faces.

**18. (Canceled)**

**19. (Original)** The method as recited in claim 1, further comprising exaggerating one of a shape and a size of a facial feature.

**20. (Currently Amended)** A system, comprising:

means for rendering a facial image into a drawing;

means for comparing relationships among facial features in the drawing to corresponding relationships in reference facial images and associated reference caricatures in a database of reference facial images and corresponding reference caricatures characters drawn by an artist, wherein the means for comparing is facilitated by a kernel regression technique that assigns various weights to the facial images and associated caricatures based on a similarity to one or more relationships among facial features in the drawing; and

means for exaggerating at least one relationship among facial features in the drawing based on the corresponding relationships in the reference facial images and associated reference caricatures, caricatures; and

wherein a degree of exaggeration for each facial feature to be exaggerated is user-adjustable.

**21. (Original)** The system as recited in claim 20, further comprising means for constraining the exaggerating to maintain the facial image of the drawing within a range of probable faces.

**22. (Original)** The system as recited in claim 21, further comprising:  
means for deriving a map representing differences between the drawing of the facial image and the facial image after the exaggerating;  
means for selecting one of the associated caricatures based on a similarity to the map; and  
means for conforming the exaggerating to the caricature.

**23. (Original)** The system as recited in claim 22, wherein the means for selecting includes means for performing a maximum likelihood technique.

**24. (Currently Amended)** The system as recited in claim 22, further comprising means for variably combining the drawing of the facial image with the selected reference caricature in order to produce a variably exaggerated caricature of the facial image in the drawing.

**25. (Canceled)**

**26. (Original)** The system as recited in claim 20, further comprising means for varying a degree of the exaggerating to be applied to a relationship among facial features while constraining the exaggerating in order to maintain the facial image within a range of probable faces.

**27. (Currently Amended)** A caricature engine embodied as instructions on a computing device storage media computer-readable storage medium, comprising:

a facial features and relationships locator to receive a facial image and locate a set of facial features and relationships among facial features in the facial image;

an exaggeration engine to compare the facial features and relationships in the facial image to facial features and relationships in a reference collection of pairs of reference facial images and associated reference caricatures stored in a database in order to determine which of the facial features and relationships to exaggerate in the facial image; and

an exaggeration constraint engine to compare exaggerations applied to the facial image with at least one selected reference caricature from the associated reference caricatures in order to conform a degree of the exaggerations to the at least one selected reference caricature, caricature; and

wherein a degree of exaggeration for each facial feature to be exaggerated is user-adjustable.

**28. (Currently Amended)** embodied as instructions on a computer-readable storage medium. The caricature engine embodied as instructions on a computer-readable storage medium as recited in claim 27, further comprising a learning engine to compare the facial features and relationships in the facial image to facial features and relationships in the reference collection by applying a kernel regression technique.

**29. (Currently Amended)** The caricature engine embodied as instructions on a computer-readable storage medium as recited in claim 27, further comprising a variable warping engine to variably combine the facial image with the at least one selected reference caricature in order to produce a variably exaggerated caricature of the facial image, while maintaining the variably combined facial image and caricature within a range of probable-faces faces.

**30. (Currently Amended)** A user interface, comprising:

- a first display area to depict a facial image;
- a second display area to depict variably exaggerated facial features and relationships among the facial features of the facial image;
- a third display area to depict a caricature of the facial image; and
- a variable exaggeration controller to control a degree of variable exaggeration applied to one or more facial features and relationships in the facial image; image,

wherein the facial image, the variably exaggerated facial features, and the caricature are obtained by a process that includes:

- receiving a facial image;
- creating a line-drawing from the facial image;
- computing a set of semantic facial features from key points of a face in the facial image to describe a geometric shape of the face;
- comparing relationships among the semantic facial features to corresponding relationships between unexaggerated and exaggerated features in reference facial images and associated reference caricatures in a reference database of caricatures drawn by an artist;
- applying a kernel regression to select some of the semantic facial features for caricature exaggeration and to exaggerate the semantic facial features into exaggerated features, wherein a nonlinear mapping between corresponding unexaggerated and exaggerated features in the reference database is learned via the kernel regression;
- generating an exaggerated face shape by applying a maximum likelihood estimation (MLE) to the exaggerated features; and
- morphing the line-drawing into the exaggerated face shape to create a facial-caricature; caricature,

wherein:

- wherein for each semantic facial feature to be exaggerated the degree of exaggeration is determined by the kernel regression; and

wherein the degree of exaggeration of each feature to be exaggerated is adjustable by a user.

**31. (Original)** The user interface as recited in claim 30, wherein the first, second, and third display areas are shown simultaneously.

**32. (Original)** The user interface as recited in claim 30, further comprising a selectable list of facial features and relationships to be selected for variable exaggeration.

**33. (Original)** The user interface as recited in claim 30, further comprising means for manually adjusting a size of a single feature or relationship.

**34. (Original)** The user interface as recited in claim 30, further comprising means for manually changing a shape of a facial feature in one of the display windows.

**35. (Currently Amended)** A computing device storage media ~~computer readable storage medium~~ containing instructions that are executable by a computing device to perform actions comprising:

comparing relationships among facial features in a facial image to corresponding relationships in a collection of reference facial images and associated reference caricatures using a kernel regression technique, wherein the

kernel regression technique assigns various weights to the reference facial images and associated reference caricatures in the collection based on a similarity to one or more relationships among facial features in the facial image;  
and

exaggerating at least one relationship among facial features in the facial image based on the ~~comparing; comparing,~~

wherein the exaggerating includes applying a kernel regression technique and the degree of the exaggerating is user-adjustable.

**36. (Currently Amended)** The computing device storage media computer-readable storage medium as recited in claim 35, the actions further comprising instructions to constrain constraining the exaggerating to maintain the facial image within a range of probable faces.

**37. (Currently Amended)** The computing device storage media computer-readable storage medium as recited in claim 35, the actions further comprising instructions to:

~~derive~~ deriving a map representing differences between the facial image and the facial image after the exaggerating;

~~select~~ selecting a reference caricature from the collection based on a similarity to the map; and

~~conform~~ conforming the exaggerating to the reference caricature, wherein if exaggeration of a relationship varies beyond a threshold from a corresponding

relationship in the reference caricature, then a degree of the exaggerating is altered to conform the relationship to the reference caricature.

**38. (Currently Amended)** The computing device storage media computer-readable storage medium as recited in claim 37, wherein the selecting includes a maximum likelihood technique.

**39. (Currently Amended)** The computing device storage media computer-readable storage medium as recited in claim 35, the actions further comprising instructions to combine combining the facial image with the caricature in order to produce a variably exaggerated caricature of the facial image.

**40. (Canceled)**

**41. (Currently Amended)** The computing device storage media computer-readable storage medium as recited in claim 35, the actions further comprising instructions to allow allowing a user to vary a degree of the exaggerating to be applied to a relationship among facial features while constraining the exaggerating in order to maintain the facial image within a range of probable faces.

**42-44. (Canceled)**

**45. (Currently Amended)** An automated method, comprising:

collecting reference pairs of facial images, wherein each pair includes an unexaggerated facial image and a caricature of the unexaggerated facial image;

receiving a facial drawing to compare with the pairs of reference facial images;

iteratively comparing characteristics of the facial drawing with characteristics in the reference pairs; and

selecting one of the reference pairs via a kernel regression technique as a model for variably exaggerating at least part of the facial ~~drawing~~, and drawing, wherein the degree of variable exaggeration via the kernel regression technique is user-adjustable.

**46. (Original)** The automated method as recited in claim 45, wherein the characteristics include relationships among facial features in the facial drawing.

**47. (Previously Presented)** The automated method as recited in claim 45, wherein the iterative comparing uses a kernel regression technique.

**48. (Currently Amended)** The automated method as recited in claim 45, wherein the iterative comparing constrains the variable exaggeration of a relationship among facial features in the facial drawing to a degree of exaggeration of a corresponding relationship in the reference pair-model.